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# REPORT ON
# CONVERSION OF SURPLUS POTATOES TO STABLE FORM

By Paul W. Edwards, Roderick K. Eskew,
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# CONVERSION OF SURPLUS POTATOES TO STABLE FORM

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## I. INTRODUCTION

The mounting surplus of white potatoes which this year may reach 100 million bushels has emphasized the need for converting them to a stable form wherein they may be conveniently stored, shipped and utilized for feed or fermentation.

This report covers a survey which has been made of the methods tried commercially in this country, as well as alternate procedures which have had preliminary investigation on a pilot-plant scale at the Eastern Regional Research Laboratory. [Pending receipt of commercial types of equipment for more thorough pilot-plant studies, this preliminary information is presented covering the advantages and disadvantages of each method and some estimated costs.]

The utilization of white potatoes for non-food uses has been developed to a high degree in Germany and full information as to the German techniques should eventually be obtained to supplement our own studies.

## II. SUMMARY AND CONCLUSIONS

A survey of the various ways of drying potatoes commercially for feed has been made and the comparative techniques and costs are presented together with improved methods developed on a pilot-plant scale at the Eastern Regional Research Laboratory. Preliminary Consideration has also been given to preparing a feed sirup by hydrolyzing ground potatoes with acid, but unlike commercial operations no pressure was employed in the early experiments. The costs of the process are shown in the following table:

| | Sirup by Acid Hydrolysis | Dehydration Grind, press regrind and Drum Dry (ERRL) | Dehydration Grind, press and Dry in Roto Louvre | Dehydration Grind, press, Regrind and Dry in Steam Tube Dryer (ERRL) |
|---|---|---|---|---|
| Cost per gallon | $.0596 | | | |
| Cost/ton dry solids | 38.80 | 30.60 | 26.80 | 26.20 |
| Cost/ton (12% Moisture) | | 27.00 | 23.60 | 23.00 |

The cost of the hydrolyzate is considered to be too high especially in view of the bitter, salty and non-sweet character of the product. Enzymatic hydrolysis is being investigated although its cost will be higher.

An analysis of the economics of salvaging surplus potatoes by drying them by the cheapest known method ($23 per ton) shows that for ten percent return to be obtained on the investment, the raw potatoes would have to be delivered at the plant for about $1.21 per ton. Such a proposition would not tempt private capital because of the relatively small return, the seasonal character of the operations and the uncertainty of raw material supply. If the process were government sponsored to absorb some of the cost of supporting potato prices, there would be recovered at most $1.66 per ton of potatoes which had been bought at about $43.00 per ton. These figures

are based on careful process cost estimates, and an assumed value of the product of 9/10 that of corn, corn being priced at $1.00 per bushel. Even if corn were priced at $1.50 per bushel or the cost of drying were reduced by $5.00 per ton of product, the proposition would still be economically unsound.

## III. DETAILS

### A. Drying Pressed Potatoes in Rotary Dryers

#### 1. True Food Dehydrators, Inc.

What is perhaps the simplest and cheapest method thus far commercially employed in this country for the conversion of white potatoes to stable form is the one developed by the North Dakota Research Foundation. This was used by True Food Dehydrators, Inc. of East Grand Forks, Minnesota.

The process consists of washing the potatoes in the conventional manner, grinding them in a hammermill using a screen with one-half inch openings, liming the pulp, dewatering it to about 65% moisture by pressing and then drying it in a Roto Louvre dryer. The factory had a capacity of 60-75 tons of raw potatoes per 24-hour day, or about 12-15 tons of dry product containing 12% moisture. In the fall of 1946 the factory was destroyed by fire. A larger unit employing the same process is under construction.

The costs of True Food Dehydrators, Inc. are of course confidential and probably lower than those in a plant operated independently of other potato processes. Their situation permits distribution of superintendence costs over various operations. It is estimated that the overall cost of producing a dehydrated product by this process in an independent plant would be about $23 per ton counting the potatoes at no cost.

(a) Operating procedure: Washed potatoes are ground in a No. 10 John Deere hammermill equipped with special hammers. A mill speed of 1300 RPM instead of 3600 RPM, its rated speed, produces a pulp that can be dehydrated better in subsequent operations. A mill screen with one-half inch openings is usually used. The size of screen hole depends upon the variety and condition of the potatoes. The milling objective is to keep the pulp particles at the maximum size that can be satisfactorily pressed. About 0.8 percent lime on the slurry basis is added to assist in the subsequent mechanical dewatering of the slurry. The amount of lime depends upon the condition of the potatoes; it should be held at the minimum required for satisfactory dewatering.

Pressing is done in the largest size Davenport press which has a capacity of about 75 tons of ground potatoes per 24-hour day. In a typical run 62% of the water in the original potatoes was removed by the press. This water contains 2.4% suspended solids, practically all of which is starch, and 5.5% dissolved solids. About 20% of the potato solids are lost in the press water. In the spring months when the sugar content of the potatoes is higher, the dissolved solids are higher and the losses are greater. The cake as removed from the press contains 65% moisture. Since the final product contains 12% moisture, only 35% of the original water must be evaporated in the dryer.

A Roto Louvre dryer five feet in diameter and 20 feet long manufactured by the Link Belt Company dried the press cake. The dryer was directly heated by burning lignite coal in a chain grate stoker-fired furnace. The temperature of the gases entering the dryer was maintained between 700°F. and 800°F., while the temperature of the gases leaving the dryer were about 240°F. The product left the dryer at 140°F.

A temperature below 700°F. was considered impractical because of the tendency of the potatoes to stick to the dryer. This high entering gas temperature thus necessitates the use of a direct fired dryer. Since the product contains a large amount of finely divided starch there is obviously an explosion hazard. This was believed to be the cause of the fire which destroyed the plant. The dried potato pulp has been used for stock feed, alcohol production and when mixed with other feeds, such as alfalfa meal, has been formed into pellets for poultry feed. A typical analysis of the product is as follows:

| | |
|---|---|
| Moisture | 10% |
| Starch | 66% |
| Total sugars | 2.3% |
| Nitrogen | 0.89% |
| Ash | 6.2% |

(b) <u>Advantages and disadvantages:</u> The chief advantage of the process is that it is simple and relatively cheap. The disadvantages are that a hazard is involved in using a direct heat dryer with material containing finely divided starch and the fact that in pressing the potatoes to reduce the cost of drying, entrained solids are lost. This loss constitutes about 20% of the solids originally in the potatoes. Nearly all of the suspended solids is starch and could be partly recovered by sedimentation. Otherwise, in some areas a stream contamination problem would arise.

(c) <u>Improved procedure of Eastern Regional Research Laboratory:</u> In order to find a safe and cheaper method experiments were made in the pilot plant at the Eastern Regional Research Laboratory. These showed that if the moisture in the potatoes is reduced by batch pressing below about 45% the resulting product can be dried in a steam tube dryer without sticking. The sticking of potatoes during drying has always constituted a problem and it is this factor which heretofore necessitated the use of direct heated dryers with the attendant hazard. Moistures of 45% and lower were obtained in the pilot plant using a conventional cider press. Such an operation would of course not be feasible commercially with potatoes because of the high labor cost. However, the desired low moisture can be obtained by blending dried product with material pressed to 65% in a continuous press. Blended material having 45% moisture dries without sticking. This procedure is frequently employed to prevent sticking in steam tube dryers.

The process would then consist of grinding washed potatoes in a hammermill with slicing-type blades using a screen with 1/2-inch holes, incorporating lime in a mixing conveyor, pressing in a Davenport to 65% moisture, regrinding in a hammermill having about 1/4-inch holes, admixing dried product to reach 45% moisture, and drying in a steam tube dryer. The regrinding in a hammermill is necessary to facilitate drying as the original coarse grind, which is optimum for pressing, dries very slowly.

We believe this to be one of the cheapest of all methods for converting potatoes to stable form. The cost should be about $23.00 per ton of product having 12% moisture. In contrast to the True Food Dehydrator's process, it is entirely safe. The only disadvantage is the loss of 20% of the potato solids in the press water. This is a concomitant of pressing and can be avoided only at the greater expense of evaporating about twice the amount of water.

?

also stream pollution ?

B. Drying Sliced Potatoes in Rotary Dryers

1. American Crystal Sugar Co.

During 1944 attempts were made to utilize beet sugar factory equipment for the drying of potatoes for feed and fermentation. The experience of the Chaska and East Grand Forks plants of the American Crystal Sugar Company in Minnesota was typical. The details of their operations may be found in an article by Donald L. Stewart and A. M. Cooley in Sugar, August 1945.

The process consisted of washing potatoes and slicing them with a modified sugar beet slicer. The slices were washed to remove surplus starch and then drained over a screen to about 85% moisture. They were then pressed in a Bromberger press which left the pulp with 76% moisture. This was then dried in Büttner rotary, direct heat, parallel flow, beet pulp dryers.

This process was considered unsatisfactory because of the unsuitability of beet slicers to slicing soft potatoes even after modification of the slicers, the high water content of the material fed to the dryers, the low capacity of the dryers, the tendency of the potatoes to stick during drying and the nonuniformity of the product, i.e. pieces were case hardened on the surface and under-dried in the center.

Insufficient data are available to permit of cost estimates on this process and they would not be particularly significant because of the technical difficulties in operation. The costs would undoubtedly be higher than that of the process used by True Food Dehydrators, Inc. because of the higher moisture content of the material going to the dryers and low dryer capacity when handling potato slices.

(a) Operating procedure: Because of the difficulties encountered in carrying out this process the details are given here by excerpts from the article in Sugar.

"The machinery and methods for unloading and handling beets needed only slight modifications to adapt them to the unloading and handling of potatoes. The low grade tubers to be dried were loaded into open gondola cars or trucks and shipped to the sugar factories where they were to be processed. Many of the potatoes were frozen in transit, but this was not necessarily detrimental to the drying process. The gondola cars or trucks were unloaded at the wet hopper and were conveyed by water in the regular fluming system. The potatoes passed through the Dalton trash catcher and the Franklin stone catcher, where some of the debris was eliminated.

However, dried stems and sprouted potatoes were not entirely eliminated and presented problems not encountered with beets and causing a great deal of difficulty in slicing operations.

"Prior to actual operation, consideration was given to transfer of the slicing equipment to the drying plant. This would have had the advantage of eliminating the conveyors; however, the transfer of equipment was considered to be impractical because of the cost involved in moving not only the slicing equipment, but also the washing equipment which was considered advantageous to the process. The plan of routing the potatoes through the main house entailed the least amount of material change, so this practice was adopted. As the potatoes entered the beet washer room they were elevated by the regular beet wheel to the beet washer where they received the regular washing treatment. Part of the stems and sprouts were eliminated by the flume water, but it was found necessary to pick manually as the potatoes passed over the picking table. After leaving the picking rolls the potatoes were elevated to the Chronos automatic scale, weighed, and dumped into the slicer hopper.

"Several problems that were not evident in the experimental work conducted prior to the processing run complicated the slicing operation. In experimental work there was no opportunity to study cutter reaction because the work was carried out with a single unmounted knife block, consequently the operational technique of the Maguin cutters had to be developed as the operation progressed. The Maguin beet slicer is constructed to accommodate ten knife blocks such as are illustrated. Each block is made up of a set of six knives whose corrugated cutting surface is presented above an adjustable bar so that the cutting edge may be increased or decreased. The assembled knife blocks are fitted about the circumference of the slicer wheel and the material to be sliced is forced against the inside cutting surface. In experimental work, where potatoes were forced across a stationary knife block, cuttings of excellent form were obtained. There was very little maceration and the number of cells ruptured was at a minimum. When actual slicing operations began it was found that sprouts and stems plugged the knives and pulping rather than slicing resulted. To overcome these difficulties manual picking of stems and sprouts was carried out; also reduction of cutter speed from 110 RPM to 50 RPM was adopted to decrease the tearing tendency of the knives. This combination of methods helped to produce better cuttings but good clean "shreds" were the exception rather than the rule. Reduction of cutter speed had a secondary motive in the reduction of the amount of material sliced. The amount of sliced potatoes that a 10-block Maguin cutter produced far exceeded the capacity of the drier units. To correct this situation, blank knife blocks, on which metal plates had been welded, were inserted until all but two of the ten blocks in a cutter were blanks. The number of blanks used controlled the volume of sliced potatoes to the drier and at times it was found necessary to produce more cuttings by inserting another knife block. This method of controlling the volume made it possible to leave the slicer unit in continuous operation, thus delivering a steady flow of material to the drying unit.

"The transfer of the sliced potatoes from the slicers to the drying plant was considered possible by two methods. The first method considered was by belt conveyors which could be arranged to carry the sliced material to the pulp drier scroll and elevator system and thence to the drier units. The second method was through the regular beet pulp pumping system. This pumping method required the introduction of a sufficient volume of water to facilitate the pumping operation. The idea of introducing water into a material to be dried seemed to favor the conveyor system, but experimental data showed a tendency for the surface starch on the unwashed slices to gelatinize and agglomerate into balls which could not be dried. With this information available, the pumping system was serviced and put in condition for immediate service should the conveyor method prove unsatisfactory. This proved an expedient move, for after a short run using the conveyor system it was necessary to shut down the driers and remove the gelatinous mass from the drier drum, since the starch on the surface of the cuttings confirmed the experimental results, and the material "balled" to the extent that efficient drying could not be done.

"As the pumping system was finally established, the sliced potatoes left the slicing unit and traveled down the conveyor system to the diffusion cell nearest the pulp pump. A funnel and spout were arranged in the cell to direct the material into the throat of the pump. A stream of water flowed into the funnel in sufficient volume to make the cuttings fluid. The mixture of slices and water was pumped to the drying plant and discharged into the pulp faenger, which is a dewatering device consisting of an inclined slotted screen over which the potato shreds were moved by wooden drags. The drained slices left the faenger at about 85% moisture and were conveyed by a scroll to the Bromberger presses. The pressed potato pulp emerged from the presses at 76% moisture and entered the rotary Büttner driers. The driers were rotary, direct-heated, parallel feed drums, heated by coal fired on chain grate stokers. The internal baffling system of the driers is shown in an illustration. Each drier was forty feet long and eight feet in diameter and turned at a speed of four RPM. The hot gases were drawn through the driers by means of exhausters. The drying characteristics of sliced potatoes were quite different from the drying qualities of residual beet pulp, and consequently a drying technique had to be developed by trial and error. The presence of starch in the potatoes caused considerable sticking and balling-up in the drums, a characteristic not found in residual beet pulp containing mostly pectins and cellulosic substances. The starch particles also tended to gelatinize and form a hard outer layer, which slowed down the drying rate considerably. Charring and burning resulted when the furnace gases were held at the levels usually employed in drying beet pulp and it was found necessary to lower the inlet temperature from 1100°C. to about 700°C. for satisfactory drying conditions.

"The yield of dried potatoes produced from a unit volume of material introduced into the drying system was roughly three times the yield obtained from residual beet pulp. This increased yield resulted in a very marked reduction of feeding rate as compared to the rate of

introduction of beet pulp. The control of moisture and cooling of the final product presented a serious problem. It was believed that moisture contents of 12% or less would be suitable for storage. However, the nature of the potato slices caused them to case-harden or scorch on the outside layer, while the moisture content of the center of the particle might be quite high. The heat of the particle caused the voltalization of this water within the particle with resulting accumulation of surface condensate and a subsequent heating in storage. To overcome this difficulty it was decided to reroute the dried material from one hot drum through a cooling drum where air at room temperature was drawn through, thus allowing the particles to attain moisture equilibrium. The material was shipped in two ways. At the outset the dried pulp was weighed over the regular automatic pulp scales and packaged in burlap bags. Bulk loading with a pneumatic conveyor moving the material directly from the drier discharge to the railroad cars proved to be a satisfactory method of handling after a suitable blower was found.

Operating Data - 8 Hour Run

"Tons potatoes sliced, 305.5. Moisture content of potatoes to drier, 76.8%. Tons of product, 49.65. Moisture content of product, 12.9. Fuel fed to both driers, bituminous screenings, 31.000 pounds. Ash from boiler stokers used to dilute screenings, 1,500 pounds. Analysis of bituminous screenings: moisture, 2.4%; ash, 9.3%; B.T.U., 13,068. Ultimate analysis of bituminous screenings: H, 4.99; C, 72.58. (As received basis). Analysis of ash from boiler stokers: moisture 13.4%; combustible, 17.2%. Average $CO_2$ content of exit gases of both driers, 3.1%. Temperature of air to stokers, 60°F. Humidity of air to stokers, 0.005 lb./lb. dry air. Average temperature of exit gases, 230°F. Temperature of product leaving driers, 134°F. Temperature of gases entering driers, 1400°F. (This temperature reading may only be used as an indicator of temperature variations, since it is obtained by a thermocouple installed in sight of the fuel bed and therefore affected by radiation). Temperature of potatoes to drier, 95°F. Heat utilized in driers in evaporating moisture from potatoes, 71%. Consumption of water in pumping, washing, fluming, etc., 1100 gal./min. Recovery of dry solids, 64%.

"The final product varied in appearance according to the treatment received, but a typical sample of the dried material had a glossy horn-like surface, colored by the furnace gases. The color ranged from a yellowish white to a dark brown or black. The chemical analysis of a typical sample of dried potatoes showed that they contain; moisture, 10.8%; ash, 3.28%; crude fat, 0.50%; crude fiber, 2.67%; crude protein, 8.07%; nitrogen free ext., 74.68%. The dry solids analyzed 65.63% starch."

(b) Advantages and disadvantages: The only advantage that we see in this process is that use can be made of idle beet sugar factories. The preponderating disadvantages are fully explained in the above excerpt.

2. Utah-Idaho Sugar Company

It has been reported that the Utah-Idaho Sugar Company will attempt to carry out this process early in 1947 at the end of this season's beet sugar

operations. It is their plan to make the pieces smaller than those used by the Crystal Sugar Company.

### 3. E. H. Beer Co.

Attempts are now being made at the Baltimore plant of E. H. Beer Company to dry sliced potatoes in a modified Challenger dryer. This dryer is manufactured by the J. B. Beaird Company of Shreveport, Louisiana, and is extensively used for drying sweet potatoes. However, without modification it is unsuited to the drying of sliced white potatoes because of their tendency to stick together and to the shell of the dryer. This is substantiated by a letter from the manufacturers to Mr. Robinson, Vice-President of Farm Crops Processing Corporation (See Appendix). One of the Challenger dryers has been modified by the E. H. Beer Company so that sticking has been eliminated. The modification consists of a device that permits the surface of the sliced potato to be dried sufficiently so that the slices will not stick to each other or to the surface of the dryer.

This device consists of a truncated cone constructed of heavy stainless steel wire mesh having one-half inch square openings. The smaller opening of the cone is 12 inches in diameter while the larger opening is 48 inches in diameter. The cone is about 40 inches long. It is attached to the inside of the drying chamber, at the feed end in such a manner that the axis of the cone that passes through the centers of the openings coincides with the axis of the dryer.

The sliced potatoes are fed through the 12-inch opening by means of a chute from the slicer which is located on top of the dryer. As the dryer revolves, the potato slices slide or roll down the inside of the cone until they reach the wall of the drying chamber. While the slices are in the cone, they are subjected to the hot gases direct from the combustion chamber in such a manner that the surfaces of the slices are apparently dried sufficiently to prevent them from sticking.

The discharge end of the dryer has been changed so that the product will be removed immediately when it reaches the end of the dryer. This modification tends to prevent overheating and ignition of the product.

The combustion chamber end of the dryer has been elevated about ten inches, so that the dryer has a slope toward the discharge end of ten inches in 45 feet.

The speed of the shredder has been reduced from 1100 RPM to 500 RPM.

Patent applications have been made for these modifications.

The following observations were made during a test run at Baltimore by a representative from this Laboratory:

Sliced potatoes were fed into the dryer at a very low rate, about 500 to 600 pounds per hour which is equivalent to 111 to 134 pounds of final product at 10 percent moisture. The product was dry but rather dark in color. The color could probably be attributed to poor temperature control and to other conditions that might be remedied.

The proposed method for drying the potatoes on a large scale is to feed about 1400 to 1800 pounds of sliced potatoes per hour to each of three dryers. The combined product from the three dryers is then fed to a fourth dryer under conditions that will result in a finished product with 10% moisture. About 934 to 1200 pounds per hour of product would thus be obtained from four dryers or an average of about 234 to 300 pounds of product at 10 percent moisture per dryer.

A test was made in the experimental dryer wherein about 2200 pounds of potatoes were used in one hour. The temperature of the inlet gases was supposed to be about 1400°F. Even at this high feed rate there was no objectionable sticking of potato to the dryer. The product as it came from the dryer was calculated to contain about 50 percent moisture. Much of the product was in rather loosely formed balls. The material from this dryer was fed to a second Challenger dryer without any modifications except that the knives were removed from the shredder or slicer. The temperature of the gases entering this dryer was maintained at about 1000°F. The loosely formed balls of potato slices referred to above were mostly broken up in the second dryer.

Some of the product as it was removed from the second dryer consisted of well dried individual slices and some was scorched. Much of it, however, was too high in moisture and had to be spread on the floor to prevent overheating.

This trial run did not produce a satisfactory product. Based on the fact that the modified dryer can be operated to prevent the potato slices from sticking together or to the dryer, it is believed that a method may be developed to produce a satisfactory product.

The basic weaknesses of this method of drying potatoes are:

(1) the large amount of water that must be evaporated per pound of product at 10 percent moisture (about 3.5 pounds), and

(2) the probable slow evaporative rate characteristic of case hardened potato slices.

It has the advantage of entailing no loss in potato solids nor stream contamination.

## C. Use of Drum Dryers

### 1. The A. Hammer Cooperage Company

A method reported to be widely used in Germany and successfully carried out on a commercial scale in this country by the A. Hammer Cooperage Co. at Marlboro, New Jersey, consists of the following steps:

The potatoes are washed in a conventional manner, cooked under pressure, mashed, and dried on a drum dryer. The unit at Marlboro operated during the spring and summer of 1946 using potatoes shipped from the south until New Jersey potatoes became available. Operations have been discontinued because of the availability of grain for fermentation.

(a) Operating procedure: The potatoes are delivered in burlap sacks and are charged into the washer, which consists of three separate compartments with a perforated semi-cylindrical screen in the lower part of each compartment. The holes in the screen are 1/2 inch in diameter. The purpose of the screen is to hold back the potatoes and larger stones while the dirt is carried away by the water. The potatoes are moved forward through the washer by blades rotating at 24 RPM and having a clearance of 2 inches from the screen. The last set of blades in each section is equipped with perforated buckets to lift the potatoes into the succeeding compartment without carrying along the stones.

The washed potatoes move vertically by bucket conveyor to a feed hopper located above the cooker. From the hopper potatoes are charged into the cooker. The cooker is a vertical, cylindrical, digester, with conical bottom and has a capacity for 6000 pounds of potatoes. Steam is introduced at 2 pounds pressure at the top of the cooker and the condensate drains off at the bottom which is open to the atmosphere. This is continued until uncondensed steam appears at the bottom, which takes about thirty minutes. The cooker is then closed and steam is introduced at the bottom until 10 pounds of pressure is developed. This requires five minutes. This pressure is maintained for ten more minutes. The water is then discarded and the cooked potatoes are discharged into the disintegrator by blowing rapidly through a 12-inch gate valve at the bottom of the cooker.

The disintegrator is a hopper-shaped unit equipped at the bottom with a rotating shaft (80 RPM) having 8-inch long, claw-shaped knives spaced every two inches. The disintegrated material is withdrawn by a screw conveyor located immediately below the knives. This conveyor terminates above the double drum dryer and the product is withdrawn from it by three adjustable slide gates located in the bottom of the conveyor trough.

The double drum dryer is an old unit previously employed for the drying of brewer's wastes. It was manufactured by the Buffalo Foundry Machine Company. The drums are 32 inches in diameter and 91 inches long. They rotate inwardly toward each other and have an adjustable clearance. The drive has been modified to give a speed of approximately 2 RPM and 95 pounds steam is used in each drum. A scraper blade removes the material from the drums after almost one complete revolution, and it falls into a screw conveyor. It is then bagged for storage. The drum surfaces were not polished and showed severe pitting and rust.

(b) Advantages and disadvantages: The only disadvantage of this process is its cost. Stream contamination is negligible as its only source would be from the condensed steam used in cooking the potatoes. Practically all of the potato solids are obtained in the finished product. No dust explosion is entailed.

2. Alternate Procedure of ERRL

Pilot-plant experiments made at the Eastern Regional Research Laboratory to determine whether the process could be further simplified and cheapened by eliminating the cooking process entirely and reducing the moisture content of the feed to the drum dryers. A process was worked out whereby the washed potatoes are coarsely ground in a hammermill having a one-half inch screen, limed and then dewatered to between 60%

and 65%. This is the same procedure as used in the first stages of the True Food Dehydrators, Inc. process. Such a product cannot be dried on drum dryers, but if it is passed through an attrition mill the product acquires a pasty character resembling cooked mashed potatoes and it can be fed directly to a drum dryer and dried by the same general procedures as used for cooked mashed potatoes at the A. Hammer Cooperage plant.

The saving in drying costs and increased capacity of the dryers is apparent when we realize that in the conventional process cooked potatoes fed to the dryer contain 5.2 pounds of water per pound of dry material. Thus for each pound of dried material produced 3.7 pounds less water must be evaporated than in the conventional process.

It is estimated that the cost of this process would be about $27.00 per ton of product containing 12% moisture and much cheaper than the conventional drum drying process because of the smaller amount of water to be evaporated. When the potatoes are processed without the use of lime, the product is in the form of a light brown crepe tissue. It has a palatable toasted flavor suggesting possible food uses. Without lime and by peeling the potatoes, the process might be used for making potato flour.

D. Preparation of a Hydrolyzate for Feed

1. Acid Hydrolysis

It was suggested that a feed molasses could be prepared simply on the farm by grinding the washed potatoes, hydrolyzing the starch with acid and partially neutralizing with alkali.

When pilot-plant experiments were undertaken it was found that in order to make the cheapest possible product it was necessary to carry out the hydrolysis with fairly strong acid, e.g. 2% hydrochloric in order to offset the very thick consistency resulting from gelatination of the starch. If this were not done, expensive specialized agitating equipment would be necessary. The pH of the hydrolyzate so produced was 0.98. Partial neutralization was done to a pH of 4.0 to 4.5 using sodium hydroxide since the soda ash originally proposed caused excessive foaming. This product, excluding the sodium chloride formed, contained only 20% solids and 14.4% sugars. Attempts to make a self-preserving product by concentrating this proved impractical because concentration had to be carried to the point where it was no longer fluid, corresponding to a solids content of 61% of which 10.7% was sodium chloride. The maximum concentration, consistent with fluidity was 35% solids, including the sodium chloride formed, and corresponds to 22% sugars. This product could be made stable by adding 0.1% of sodium benzoate. This probably represents the cheapest stable fluid hydrolyzate that could be produced. However, except in viscosity and appearance it bears no resemblance to molasses and has no use as a sweetener because of the salt content which is about 10% on the dry solids basis. Its estimated cost of manufacture is $38.80 per ton of dry solids content.

### 2. Enzymatic Hydrolysis

Currently, experiments are being made on hydrolyzing the starch with enzymes, which will entail a higher manufacturing cost but will produce a product that at least is not salty. Laboratory results have shown that it will not be sweet. The non-sugars present contribute a strong bitter taste. From our experience to date the preparation of a hydrolyzate by either acid or enzymatic treatment does not look like a practical means of salvaging surplus potatoes.

## IV. OVERALL ECONOMICS OF POTATO DRYING

It has been shown that one of the cheapest methods of converting white potatoes to stable form is to grind, press and dry them at an overall cost of about $23.00 per ton of product (12% moisture). This assumes the potatoes to be delivered to the factory free and includes all costs except those for sale and distribution of product.

In order to determine whether such a proposition could be profitable let us assume a probable market value for the product in comparison with other feeds and assuming a return on the investment of ten percent, determine at what cost the potatoes would have to be delivered at the factory to realize this return.

According to data on the feed value of various products as given in Morrison's "Feed and Feeding" it is estimated that the value of dried white potatoes should not exceed 9/10 that of #2 yellow corn. This is based on the relative net energy values. As shown in Appendix, the feed value is equal to or slightly better than corn for cattle, but much inferior to corn for sheep and hogs. With corn at $35.70 per ton ($1.00 per bu.) dried potatoes would thus be $32.15 per ton. At a manufacturing cost of $23 per ton the difference would thus be $9.15 per ton or $15,550 per year for a plant producing 1700 tons of product annually. The investment to produce this quantity of feed annually would be about $42,000. (See detailed cost estimate on the steam-tube dryer process in Appendix.) A ten percent return on this investment would be $4200, thus leaving $11,350 to be available for buying and delivering potatoes to the drying plant. This amounts to only $1.21 per ton of raw potatoes or 6¢/100 lbs. With potatoes at no cost this figure would permit shipments only limited distances. The operation would have to be carried out in areas of heavy potato production. Also it is unlikely that private enterprise would undertake such a proposition as it would be based upon a raw material of uncertain supply. Nor has any cost of distributing the feed product been considered. Thus, the drying of white potatoes for feed would seem to be impracticable as a private enterprise. It might be government sponsored to absorb some of the cost to the government of supporting potato prices. Under these circumstances the government would realize at most $1.66/ton on potatoes for which they had paid about $43/ton.

The effect of higher corn prices on the above considerations is shown in the following table. Even with corn at $1.57/bu. the picture is not significantly changed.

| CORN $/bu. | CORN $/T | Calculated Value of Dried Potatoes $/T | Delivered Price of Raw Potatoes $/T |
|---|---|---|---|
| 1.00 | 35.70 | 32.15 | 1.21 |
| 1.12 | 40.00 | 36.00 | 1.91 |
| *1.57 | 56.00 | 50.40 | 4.53 |

*Current price delivered Philadelphia.

# V APPENDIX

500 lbs $H_3PO_4$
@ 50

160
150
310
108
25 ) 418 (1.52 / ton

16.00 / tons

4000 ) 418 (10.45 ¢ gallon

Hour [illegible]
25 Tons of 60% solids glucose

# COST SUMMARY

150,000 lbs wet
30,000 lbs dry
@ 15 Tons

| | Sirup by Acid Hydrolysis | Grind, Press Regrind and Drum Dry | Grind, Press and Dry in Roto Louvre | Grind, Press, Regrind and Dry in Steam Tube Dryer |
|---|---|---|---|---|
| Capital Costs | | | | |
| Equipment 30,000 | $38,395.00 ? | $48,445.00 | $41,327.00 | $30.075.00 |
| Building | 16,960.00 | 10,400.00 | 9,580.00 | 8,400.00 |
| Boilers 964 | 7,520.00 | 4,000.00 | | 3,320.00 |
| Total | $62,875.00 | $62,845.00 | $50,907.00 | $41,795.00 |
| Materials | $218.75 26.00 | $12.00 | $12.00 | $12.00 |
| Labor | 212.40 122.00 | 126.00 | 104.40 | 104.40 |
| Prime Cost | $431.15 1600 | $138.00 | $116.40 | $116.40 |
| Factory Overhead | | | | |
| Supervision | 49.60 | 49.60 | 49.60 | 49.60 |
| Power | 29.87 | 18.12 | 12.50 | 15.34 |
| Steam | 52.20 | 25.40 (Fuel) | 28.35 | 23.12 |
| Maint.& Supl. | 25.00 | 25.00 | 25.00 | 25.00 |
| Total | $156.67 | $118.12 | $115.45 | $113.06 |
| Factory Cost | $587.82 | $256.12 | $231.85 | $229.46 |
| Fixed Costs | | | | |
| Interest | 25.15 | 25.14 | 20.36 | 16.72 |
| Taxes | 10.06 | 10.06 | 8.15 | 6.68 |
| Insurance | 2.52 | 2.51 | 2.04 | 1.67 |
| Social Secur. | 3.93 | 2.63 | 2.31 | 2.31 |
| Depreciation | 66.86 | 70.29 | 57.26 | 45.99 |
| Total | $108.52 3.62 | $110.63 | $90.12 | $73.37 |
| Cost to Make | $696.34 $23.21/Ton | $366.75 | $321.97 | $314.83 |
| Cost per Pound | $0.00633 | $0.0135 | $0.0118 | $0.0115 |
| Cost per Gallon | $0.0596 | | | |
| Cost per Ton ($12\%\ H_2O$) | | $27.00 | $23.60 | $23.00 |
| Cost per Pound Dry Solids | $0.0194 | $0.0153 | $0.0134 | $0.0131 |
| Cost per Ton Dry Solids | $38.80 ? | $30.60 | $26.80 | $26.20 |

Evaporation by flash distillation would be much less
Labor & Supervision would be much less

# COST ESTIMATE

## Sirup by Acid Hydrolysis

### BASIS

125 Working Days
2,500 Bushels potatoes per day. 60 lbs. per bushel.
150,000 Lbs. per 24 hours = 6,250 lbs. per hour.
Continuous Process. Potatoes 80% water.

### CAPITAL COSTS

#### Equipment

| | |
|---|---|
| 1 Washer | $ 750.00 |
| 1 Pump, water supply | 225.00 |
| 1 Conveyor washer to hammermill | 2,600.00 |
| 2 1/32" Screen hammermills, 10 H.P. drive | 2,200.00 |
| 3 Pumps, process | 420.00 |
| 17 Wood tanks equipped with Monel turbine agitators, Monel propeller and shaft and 60'-1-1/2" Monel heating coil, each $1,200 | 20,400.00 |
| Erection and installation--Platforms and supports | 11,800.00 |
| Total Equipment | $38,395.00 |

#### Building

Sheet iron hung on structural steel frame.
Building 40' wide, 95' long = 4,000 sq.ft. floor space.
Elevation, 30' over 75', 20' over 20'.

40 x 75 x 30 = 90,000 cu.ft.
40 x 20 x 20 = 16,000 cu.ft.
Total 106,000 cu.ft.

Cost per cubic foot, including concrete floor--heat and light--
16 cents per cu.ft.

Total 106,000 x .16 = $16,960.00

#### Boilers--housed ready to run

Steam Required for Hydrolysis

6,250 Lbs. material per hour raised from 60° F. to 212° F. = 152° F.
Sp.ht. potatoes above freezing = 0.83
B.t.u./hour 6,250 x 152 x .83 = 788,500

$$\frac{788,500}{970} = 812 \text{ lbs. steam per hour}$$

Allow for radiation loss in keeping at boiling
974 Lbs. steam per hour

CAPITAL COSTS

Boilers--housed ready to run-Continued

Steam Required for Evaporation

150,000 Lbs./24 hours. 80% water.

120,000 Lbs. water; 30,000 lbs. solids

Solids to be increased from 20% to 35%

$$\frac{30,000}{.35} = 85,716 \text{ lbs.}$$

65% Water = 85,716 x .65 = 55,715 lbs. $H_2O$

120,000 -55,715 = 64,285 lbs. water to be evaporated in 24 hours.

$$\frac{64,285}{24} = 2,678 \text{ lbs. water to be evaporated per hour.}$$

0.6 Lbs. water evaporated per pound steam.

$$\frac{2,678}{.6} = 4,463 \text{ lbs. steam per hour.}$$

Total = 4,463 + 974 = 5,437 lbs. steam per hour.

Steam at 90 lbs. gauge. Enthalpy at 90 lbs. gauge = 1,188 B.t.u./lb.

$$\frac{1,188 - (62-32)}{970.3} = 1.19 \text{ factor of evaporation}$$

5,437 x 1.19 = 6,470 lbs./hr. from and at 212° F.

$$\frac{6,470}{34.5} = 188 \text{ B.H.P.}$$

Cost per B.H.P. = $40.

Total 188 x $40. = $ 7,520.00

TOTAL CAPITAL COST $62,875.00

7000
119
8330 lbs/hr from and at 212° F

$$\frac{8330}{34.5} = 241 \text{ B.H.P}$$

cost per BHP $40 ∴ 241 x 40 = 9640

# COST SHEET

$ 25.00

**BASIS**

150,000 Lbs. potatoes per 24 hours.

**MATERIAL**

Potatoes: Nil

Hydrochloric Acid: 2% on weight of water in potatoes (80% $H_2O$)

150,000 x .8 = 120,000 lbs. water

120,000 x .02 = 2,400 lbs. hydrochloric acid.

HCl = 37% HCl, therefore $\frac{2,400}{.37}$ = 6,486 lbs. HCl required.

6,486 lbs. HCl at $1.75/100 lbs. = $113.51  $ 25.00

NaOH, to Neutralize

No neutralization

$$HCl + NaOH = NaCl + H_2O$$

36 40 58 18

$$\frac{36}{40} = \frac{2,400}{X};\ X = \frac{40 \times 2,400}{36} = 2,666 \text{ lbs. NaOH.}$$

$$NaOH = 76\%, \text{ therefore } \frac{2,666}{.76} = 3,508 \text{ lbs. NaOH}$$

3,508 lbs. NaOH at $3.00/100 = $105.24

Salt Formed

$$\frac{36}{58} = \frac{2,400}{X};\ X = \frac{58 \times 2,400}{36} = 3,866 \text{ lbs./24 hours.}$$

Water for Washing

Water taken from river--have only pumping cost. This item is shown under power cost.

Total Material Cost $218.75

**LABOR**

Per Shift. Three 8-hour shifts.

| | | | | | |
|---|---|---|---|---|---|
| 1 | 2 men - Washer, | $.90/hr. | $1.80 x 8 = | $14.40 | 1 shift only |
| 1 | 1 man - Hammermills, | .90/hr. | .90 x 8 = | 7.20 | 2 shifts |
| 2 | 6 men - Tanks, | .90/hr. | 5.40 x 8 = | 43.20 | |
| 1 | 1 man - Helper, | .75/hr. | .75 x 8 = | 6.00 | |
| | | | Per Shift | $70.80 | |

Total for 3 Shifts = 3 x $70.80 $212.40

PRIME COST $431.15

3 X 35. = 105.00

14 30
14 40
64 80
18 00

111 50
25

FACTORY OVERHEAD

Supervision

| | |
|---|---|
| Superintendent \$20/day (short season), | \$20.00 |
| 2 Asst. superintendents, one per shift, \$10/day each, | \$20.00 |
| 1 Mechanic at \$1.20/hour. | \$ 9.60 |
| Total | \$49.60 |

Power

| | | | | |
|---|---|---|---|---|
| Washer, | 3 H.P., | 9.2 | 9.2 | |
| Pump, | 2 H.P., | 6. | 6.00 | |
| 2 Hammermills, | 10 H.P., | 28. | 56.00 | |
| Tanks, | 5 H.P. x 17 | | 15. | 255.0 |
| Conveyor, | 3 H.P. | | 8.4 | 8.4 |
| Pumps, | 2 H.P. | | 6.0 | 18.0 |
| | | | | 352.6 amp. |

At 220 volts--3 phase, K.W. = $\frac{352.6 \times 220 \times 1.73 \times .8}{1000}$ = 107.9

| | | |
|---|---|---|
| For 24 hours = 108 x 24 = | 2,592 | K.W.H. |
| For lighting | 5 | K.W.H. |
| Total | 2,597 | K.W.H. |

Based on \$.05/1st 1000 K.W.H./mo.; \$.03/next 3000 K.W.H./mo.;
\$.01 on all over 4000 K.W.H./mo.

25 working days per mo. 2,597 x 25 = 64,925 K.W.H. per mo.

1000 at \$.05 = \$50.00
3000 at \$.03 = 90.00
60,925 at \$.01 = 609.25
\$749.25

$\frac{749.25}{64,925} \doteq .0115$

Rate = \$.0115 per K.W.H.

Total 2,597 x \$.0115 = \$29.87

Steam

974 lbs./hr. for hydrolysis
4,463 lbs./hr. for evaporation
5,437 lbs./hr. total steam

For 24 hours. 5,437 x 24 = 130,488 lbs. steam.

Steam costs \$.40/1000 lbs.

Total 130.5 x \$.40 = \$52.20

Maintenance and Supplies \$25.00

TOTAL FACTORY OVERHEAD \$156.67

FACTORY COST \$587.82

FIXED CHARGES

125 Days operation

Interest at 5%

.05 x \$62,875 = \$3,143.75

For 125 days operation, $\frac{\$3,143.75}{125}$ = \$25.15

Taxes at 2%

.02 x \$62,875 = \$1,257.50

For 125 days operation, $\frac{\$1,257.50}{125}$ = \$10.06

Insurance at 0.5%

.005 x \$62,875 = \$314.38

For 125 days operation, $\frac{\$314.38}{125}$ = \$ 2.52

Social Security. 1-1/2% on each employee to \$2,500.

Full payroll for 125 days = \$32,750

\$32,750 x .015 = \$491.25

For 125 days operation, $\frac{\$491.25}{125}$ = \$ 3.93

Depreciation--The depreciation rates will be high due to the fact that the plant will be shut down approximately 7 months of the year.

| | | | |
|---|---|---|---|
| Building, | 10%/year = | .10 x \$16,960 = | \$1,696.00 |
| Equipment, | 15%/year = | .15 x \$38,395 = | \$5,759.25 |
| Boilers and Build., | 12%/year = | .12 x \$ 7,520 = | \$ 902.40 |
| | | Total | \$8,357.65 |

For 125 days operation, $\frac{\$8,357.65}{125}$ = \$66.86

TOTAL FIXED CHARGES \$108.52

COST TO MAKE

| | | |
|---|---|---|
| Materals | \$218.75 | |
| Labor | 212.40 | |
| Factory overhead | 156.67 | |
| Fixed costs | 108.52 | |
| Total | | \$696.34 |

YIELDS AND COSTS

150,000 lbs./24 hours
From 20% solids to 35% solids
150,000 x .20 = 30,000 lbs. solids/24 hours

Starch in solids = $\frac{12}{20}$ x 30,000 = 18,000 lbs.

Assuming complete hydrolysis

Hydrolyzation ratio = $\frac{180}{162}$

$\frac{180}{162}$ x 18,000 = 20,000 lbs.

Increase is 20,000 -18,000 = 2,000 lbs.

Therefore, potato solids after hydrolysis

30,000 + 2,000 = 32,000 lbs./24 hours

Salt produced = 3,866 lbs./24 hours.

Total weight, considering potato solids only

$\frac{32,000}{.35}$ = 91,428 lbs./24 hours

Total weight, considering potato solids + salt

32,000 + 3,866 = 35,866

$\frac{35,866}{.35}$ = 110,045 lbs./24 hours

Cost to make = $696.34

Cost per Pound--35% solids

Considering potato solids only: $\frac{696.34}{91,428}$ = $0.00762

Considering potato solids + salt: $\frac{696.34}{110,045}$ = $0.00633

| | | | |
|---|---|---|---|
| Sp.Gr. Mixture, | 65 water at | 1.0 = | 65.00 |
| | 35 solids at | 1.5 = | 23.33 |
| | 100 | | 88.33 |

Sp.Gr. = $\frac{100}{88.33}$ = 1.13

8.34 x 1.13 = 9.42 lbs./gallon

YIELDS AND COSTS-Continued

Cost per Gallon

Considering potato solids only = \$0.00762 x 9.42 = \$0.0718

Considering potato solids + salt = \$0.00633 x 9.42 = \$0.0596

Cost per Pound Dry Solids

Considering potato solids only = $\frac{\$696.34}{32,000}$ = \$0.0217

Considering potato solids + salt = $\frac{\$696.34}{35,866}$ = \$0.0194

Cost per Ton Dry Solids

Considering potato solids only = \$.0217 x 2,000 = \$43.40

Considering potato solids + salt = \$.0194 x 2,000 = \$38.80

CALCULATIONS

Wood Tanks

5' dia. x 7' deep
Allow 24" free board for boiling, agitation and foaming
5' dia. = 147 gals. per foot of depth
7 x 147 = 1,029 gallons--total capacity of tank
With 24" free board
5 x 147 = 735 gallons working capacity
Mixture: 80% water; 20% solids

| | | | |
|---|---|---|---|
| 20 | at 1.5 | = | 13.3 |
| 80 | at 1.0 | = | 80 |
| 100 | | | 93.3 |

$\frac{100}{93.3}$ = 1.07 Sp.Gr.

8.34 x 1.07 = 8.92 lbs./gallon
735 x 8.92 = 6,542 lbs. charge in tank
6,542 lbs. charge = 5,234 lbs. water and 1,308 lbs. solid
Temperature rise = 60° F. to 212° F. = 152° F.
Specific Heats. Potatoes = 0.83; water = 1.0.

| | | |
|---|---|---|
| For water = 5,234 x 1 x 152 = | 795,568 | B.t.u. |
| For solid = 1,308 x 0.83 x 152 = | 165,017 | B.t.u. |
| Total | 960,585 | B.t.u. |

Heating Coil for Tank

Steam in coil 50 lbs. gauge = 297° F.
Temperature at start 50° F., at end 212° F.

Mean temperature difference - $\frac{(297-50) + (297-212)}{2} = \frac{332}{2}$ = 166° F.

CALCULATIONS

Heating Coil for Tank-Continued

From Chart: Heat transfer rate is 35,000 B.t.u. per sq.ft. per hour per ° F.

$\frac{960,585}{35,000}$ = 27.4 sq.ft. heating surface for coil

Using 1-1/2" Monel pipe coil - 1-1/2" pipe = 2.01 ft./sq.ft. surface.

27.4 x 2.01 = 55.07 ft. of 1-1/2" Monel pipe required to heat to boiling in one hour with 50 lbs. gauge steam in coil.

Evaporating Time

10 pounds water evaporated per sq.ft. surface per hour.
5' tank diameter = 19.64 sq.ft. disengaging surface.
196.4 lbs. water evaporated/hour/tank.
Charge is 6,542 lbs.
5,234 lbs. water; 1,308 lbs. solids
Solids to be increased from 20% to 35%.

$\frac{1,308}{.35}$ = 3,737 lbs.

| | |
|---|---|
| Water + solids at 20% solids = | 6,542 lbs. |
| Water + solids at 35% solids = | 3,737 lbs. |
| Lbs. water to be evaporated per chrg/tank = | 2,805 lbs. |

$\frac{2,805}{196}$ = 14.3 hours for evaporation per charge.

Number of Tanks Required

| | | |
|---|---|---|
| Cycle: | 14 hours, 20 min. | evaporation |
| | 1 hour, 30 min. | hydrolysis |
| | 1 hour, 10 min. | charge and discharge |
| | 17 hours | cycle time |

Each tank turns 1.4 times per 24 hours. Holds 6,542 lbs.
1.4 x 6,542 = 9,159 lbs./tank/24 hours.

$\frac{150,000}{9,159}$ = 16.4 = 17 tanks required.

CALCULATIONS-Continued

Tank Cost

Tanks to be used for hydrolysis and evaporation.
Tank: 5' dia. x 7' deep.
Cypress, $.36/board foot.
Staves, 7'-6" long. 5' dia. = 15.7' circumference
15.7 x 7.5 = 117.75 board feet 1" thick
Staves 2-1/2" thick; 117.75 x 2.5 = 294.37 board feet
Bottom 5' dia. = 19.6 sq.ft.; 19.6 x 2.5 = 49 board feet
294.3 + 49 = 343 board feet total

| | | |
|---|---|---|
| Material cost for cypress, hoops and lugs, 343 x .36 = | $123.48 | |
| Erection cost, | $ 43.22 | |
| Size factor (small tank), | $ 53.30 | |
| Total cost of tank assembled = | | $220.00 |

Agitator (Turbine type)

| | | |
|---|---|---|
| 30" Monel turbine; 20" L.H. propeller | | |
| Monel shaft, 5 H.P. motor, reduction gears and outboard bearing, | $595.00 | |
| Supports, structural steel, | $ 45.00 | |
| Total | | $640.00 |

Coil-Heating

| | | |
|---|---|---|
| Monel coil in tank for heating | | |
| 60'-1-1/2" Monel pipe at $3.35/ft. | $201.00 | |
| Fabrication into coil | $125.00 | |
| Total | | $326.00 |
| TOTAL CALCULATIONS | | $1,186.00 |

Say $1,200 per tank

# COST ESTIMATE

## Grind, Press, Regrind and Drum Dry

### BASIS

125 Working Days
2,500 Bushels potatoes per day. 60 lbs. per bushel
150,000 Lbs. per 24 hours = 6,250 lbs. per hour

### CAPITAL COSTS

#### Equipment

| | | |
|---|---|---|
| 1 Washer | $ 750.00 | |
| 1 Pump, water supply | 225.00 | |
| 1 Conveyor to hammermill | 2,600.00 | |
| 1 Hammermill | 1,100.00 | |
| 1 Mixing conveyor | 385.00 | |
| 1 Syntron feeder | 115.00 | |
| 1 #1A Davenport press | 6,630.00 | |
| 1 Disc mill | 1,330.00 | |
| 2 60" x 144" Drum dryers | 15,080.00 | |
| 2 Moyno type pumps | 380.00 | |
| 2 Feeders for drum dryers | 350.00 | |
| 1 Collecting conveyor | 1,200.00 | |
| Erection and installation-- Platforms and supports | 18,300.00 | |
| Total Equipment | | $48,445.00 |

#### Building

Sheet iron hung on structural steel frame.

Building. One section 50' x 25' x 20' = 25,000 cu.ft.
Remainder 50' x 20' x 40' = 40,000 cu.ft.
Total 65,000 cu.ft.

Cost per cubic foot, including concrete floor--
heat and light--16 cents per cu.ft.

Total 65,000 x .16 = $10,400.00

CAPITAL COSTS-Continued

Boilers

6,250 lbs./hour--80% water, 20% solids

5,000 lbs. water, 1,250 lbs. solids

Davenport press removes 62% of original water and 20% of solids

5,000 x .62 = 3,100 lbs. water removed by pressing

5,000 -3,100 = 1,900 lbs. water remaining after pressing

Lose 20% of solids = 1,250 x .8 = 1,000 lbs. of solids after pressing

Material from Davenport per hour

| | | |
|---|---|---|
| 1,000 lbs. solids) | 34.4% | |
| 1,900 lbs. water ) | 65.6% | |
| 2,900 lbs. | | |

Dried to 12% moisture

$\frac{1,000}{.88}$ = 1,136 lbs. finished product/hour. (12% water)

1,136 -1,000 = 136 lbs. of water in finished product/hour

1,900 -136 = 1,764 lbs. of water to be evaporated/hour

In double drum dryers, at atmospheric pressure, it requires on the average 1-1/2 lbs. of steam/lb. of water evaporated.

1,764 x 1-1/2 = 2,646 lbs. steam/hour at 90 lbs. gauge

Enthalpy at 90 lbs. gauge = 1,188 B.t.u., therefore,

$\frac{1,188-(62-32)}{970.3}$ = 1.19 factor of evaporation

2,646 x 1.19 = 3,149 lbs. from and at 212° F.

$\frac{3,149}{34.5}$ = 91.2 boiler horsepower; say, 100 B.H.P. (heating)

Cost per boiler horsepower = $40.00

| | | |
|---|---|---|
| Total | 100 x $40.00 = | $ 4,000.00 |
| TOTAL CAPITAL COST | | $62,845.00 |

# COST SHEET

## BASIS

150,000 lbs. Potatoes per 24 hours = 6,250 lbs./hour

## MATERIAL

Potatoes: Nil

Lime:

0.8% on weight of potatoes

150,000 x .008 = 1,200 lbs./24 hours

Hydrated lime = $.01/lb.

1,200 x $.01 = $ 12.00

Water for Washing

Water taken from river--have only pumping cost.
This item is shown under power cost.

| | |
|---|---|
| Total Material Cost | $ 12.00 |

## LABOR

Per Shift. Three 8-hour shifts.

| | | | |
|---|---|---|---|
| 2 men - Washers, | $.90/hr. | $1.80 x 8 = | $14.40 |
| 1 man - Hammer & disk mills, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Davenport, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Drum dryers, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Helper | .75/hr. | .75 x 8 = | 6.00 |
| | | Per Shift | $42.00 |

| | |
|---|---|
| Total for 3 Shifts = 3 x $42.00 | $126.00 |
| PRIME COST | $138.00 |

FACTORY OVERHEAD

Supervision

| | |
|---|---|
| Superintendent $20/day (short season) | $20.00 |
| 2 Asst. superintendents (shifts) $10/day each, | $20.00 |
| 1 Mechanic at $1.20/hour | $ 9.60 |
| Total | $49.60 |

Power

| | | | | |
|---|---|---|---|---|
| | Washer | 3 H.P. | 9.2 | 9.2 |
| | Pump, | 2 H.P. | 6 | 6.0 |
| | Hammermill, | 10 H.P. | 28 | 28.0 |
| | Feeder, | | 1.36 | 1.36 |
| | Mixing conveyor, | 3/4 H.P. | 2.8 | 2.8 |
| | Davenport, | 5 H.P. | 15. | 15.0 |
| | Disc mill, | 10 H.P. | 27. | 27.0 |
| 2 | Pumps, | 1 H.P.ea., | 3.3 | 6.6 |
| 2 | Drum dryers, | 15 H.P.ea., | 38 | 76.00 |
| | Conveyor, | 3 H.P. | 9.2 | 9.2 |
| | Conveyor, | 2 H.P. | 6.0 | 12.0 |
| | | | Total | 193.16 |

At 220 volts, 3 phase, K.W. =

$$\frac{193.16 \times 220 \times 1.73 \times .8}{1,000} = 58.81 \text{ K.W.}$$

| | | |
|---|---|---|
| 58.81 x 24 = | 1,411 | K.W.H. |
| For lighting = | 5 | K.W.H. |
| Total | 1,416 | K.W.H. |

Cost of current; Based on $.05/1st 1000/mo.;
$.03/next 3000/mo.; $.01 on all over 4000 K.W.H./mo.

25 Working days per mo. 1,416 x 25 = 35,400 K.W.H./mo.

| | | |
|---|---|---|
| 1,000 K.W.H. at $.05 = | $ 50.00 | |
| 3,000 K.W.H. at $.03 = | 90.00 | $\frac{\$454.00}{35,400}$ = $.0128/K.W.H. |
| 31,400 K.W.H. at $.01 = | 314.00 | |
| | $454.00 | |

Rate = $.0128 per K.W.H.

Total 1,416 x $.0128 = $18.12

Steam

2,646 lbs./hour
For 24 hours = 2,646 x 24 = 63,504 lbs.
Steam costs 40 cents per 1000 lbs.

Total 63.5 x $.40 = $25.40

| | | |
|---|---|---|
| Maintenance and Supplies | $25.00 | |
| TOTAL FACTORY OVERHEAD | | $118.12 |
| FACTORY COST | | $256.12 |

FIXED CHARGES

125 Days operation

Interest at 5%

$.05 \times \$62,845 = \$3,142.25$

For 125 days operation, $\frac{\$3,142.25}{125} = \$25.14$

Taxes at 2%

$.02 \times \$62,845 = \$1,256.90$

For 125 days operation, $\frac{\$1,256.90}{125} = \$10.06$

Insurance at 0.5%

$.005 \times \$62,845 = \$314.23$

For 125 days operation, $\frac{\$314.23}{125} = \$\ 2.51$

Social Security. 1-1/2% on each employee to $2,500

Full payroll for 125 days = $21,950

$\$21,950 \times .015 = \$329.25$

For 125 days operation, $\frac{\$329.25}{125} = \$\ 2.63$

Depreciation--The depreciation rates will be high due to the fact that the plant will be shut down approximately 7 months of the year.

| | | | | |
|---|---|---|---|---|
| Building, | 10%/year | = .10 x $10,400 | = | $1,040.00 |
| Equipment, | 15%/year | = .15 x $48,445 | = | $7,266.75 |
| Boiler & Build., | 12%/year | = .12 x $ 4,000 | = | $ 480.00 |
| | | Total | | $8,786.75 |

For 125 days operation, $\frac{\$8,786.75}{125} = \$70.29$

TOTAL FIXED CHARGES $110.63

COST TO MAKE

| | |
|---|---|
| Materials | $ 12.00 |
| Labor | 126.00 |
| Factory overhead | 118.12 |
| Fixed costs | 110.63 |

Total $366.75

## YIELDS AND COSTS

150,000 lbs./24 hours. 6,250 lbs./hour.

Raw material 20% solids

6,250 x .20 = 1,250 lbs. solids/hour

Lose 20% solids through Davenport press

1,250 x .8 = 1,000 lbs. of solids/hour

Material to contain 12% moisture

$\frac{1,000}{.88}$ = 1,136 lbs. finished product per hour (12% $H_2O$)

For 24 hours.

1,136 x 24 = 27,264 lbs. (with 12% $H_2O$)

27,264 lbs. cost to make \$366.75

Cost per Pound

$$\frac{\$366.75}{27,264} = \$.0135$$

Cost per Ton

\$27.00

Cost per Pound Dry Solids

$$\frac{\$366.75}{24,000} = \$.0153$$

Cost per Ton Dry Solids

\$30.60

CALCULATIONS

For Feeding Lime

.8% on total mash
6,250 x .008 = 50 lbs./hour. Required feed
Syntron vibrator Model FM-1-25
Feeds hydrated lime from 8 to 250 lbs./hour
Hopper 2-1/2 cu.ft., Sp.Gr. hydrated lime 2.41
62.5 x 2.41 = 150.6 lbs./cu.ft.
2-1/2 cu.ft. = 376.5 lbs. hopper content
Enough feed for 7-1/2 hours
Power: 150 watts at 110 V.

Price $165.00

Mixing Conveyor

Handle discharge from hammermill to Davenport press
Handle 6,250 lbs./hour

Potato mash, 80% water, 20% solids

| | | |
|---|---|---|
| 80 lbs. | - 1.00 = | 80.00 |
| 20 lbs. | - 1.50 = | 13.36 |
| 100 | | 93.36 |

$$\text{Sp.gr.} = \frac{100}{93.36} = 1.072$$

62.5 x 1.07 = 67 lbs./cu.ft.

$$\frac{6,250}{67} = 93.4 \text{ cu.ft./hour for one conveyor}$$

For Class III screw conveyor, 31% of cross section material
6" screw conveyor at 30 R.P.M. gives required capacity
Can speed up to 90 R.P.M. when capacity is 140 cu.ft./hour

Power for driving

$$\text{H.P. at conveyor.}\quad \frac{ALN + CWLF}{1,000,000} =$$

$$\frac{54 \times 25 \times 20 \times 93.4 \times 67 \times 25 \times .9}{1,000,000} = .168 \text{ at conveyor}$$

$$\text{Motor required.}\quad \frac{HG}{E} = \frac{.168 \times 2}{8} = .42$$

Use 3/4 H.P. on each.

Cost. Conveyor 25' long

| | |
|---|---|
| Trough, bearings and screw. Galv. $7.50/ft. | $187.50 |
| Double worm reducer | 125.00 |
| Motor | 42.00 |
| Starter and disconnect switch | 19.37 |
| | $373.87 |

CALCULATIONS-Continued

Disc Mill

By test, 8" attrition mill did 500 lbs./hour
6,250 lbs./hour at 80% water
i.e., 5,000 lbs. water, 1,250 lbs. solids
From Davenport, 1,250 lbs. solids with 60% water

$\frac{1,250}{.4}$ = 3,125 lbs. = total throughput for disc mill

$\frac{3,125}{500}$ = 6.25. 6.25 x 50.26 = 314.125 sq.in. required,

| | | |
|---|---|---|
| therefore, cost | 18" attrition mill | $1,140.00 |
| | 10 H.P. motor | 142.00 |
| | Starter and disconnect switch | 48.00 |
| | Total | $1,330.00 |

Moyno Type Pumps (for feeder to drum dryers)

3,125 lbs./hour

| | | |
|---|---|---|
| 1,250 lbs. solids | 1.50 | 833. |
| 1,875 lbs. water | 1.00 | 1,875. |
| 3,125 | | 2,708 |

$\frac{3,125}{2,708}$ = 1.15 Sp.Gr. 8.34 x 1.15 = 9.6 lbs./gallon

$\frac{3,125}{9.6 \times 60}$ = 5.4 g.p.m.

2 Pumps at $190 each with drive, $ 380.00

Feeders for Drum Dryers

2 Feeders with drive mechanism, $175 each, $ 350.00

Drum Dryers

6,250 lbs./hour; 1,250 lbs. solids; 5,000 lbs. water
Davenport removes 62% of water of original and 20% of solids
5,000 x .62 = 3,100 lbs. water removed by pressing
Water remaining after pressing = 5,000 -3,100 = 1,900 lbs.
Lose 20% solids by pressing
1,250 x .8 = 1,000 lbs. solids/hour after pressing
Material from Davenport per hour

CALCULATIONS

Drum Dryers-Continued

1,000 lbs. solids) 34.4%
1,900 lbs. water ) 65.6%
2,900 lbs.

From test. Double drum dryer 5.8 lbs. water evaporated per sq.ft./hour
2,900 lbs. raw material from Davenport
1,000 lbs. solid + 1,900 lbs. water to dryer/hour
Dry to 12% moisture

$\frac{1,000}{.88}$ = 1,136 lbs. 1,136 -1,000 = 136 lbs. water in product

1,900 - 136 = 1,764 lbs. water to be evaporated per hour

$\frac{1,764}{5.8}$ = 304 sq.ft. required

Double Drum Dryer Sizes

| Drums | Overall Length | Overall Width | Sq. Ft. per Machine | No. Machines Calc. | No. Machines Actual | Cost per Sq.Ft. | Cost per Machine | Total Cost |
|---|---|---|---|---|---|---|---|---|
| 32" x 90" | 19'-6" | 8'-3" | 62.7 | 4.69 | 5 | $76 | $4,765 | $23,825 |
| 32" x 100" | 20'-6" | 8'-3" | 69.6 | 4.22 | 5 | 71 | 4,941 | 24,705 |
| 42" x 100" | 22'-0" | 9'-9" | 91.5 | 3.32 | 4 | 60 | 5,490 | 21,960 |
| 60" x 144" | 26'-0" | 13'-6" | 188.5 | 1.56 | 2 | 40 | 7,540 | 15,080 |

Use 2 double drum dryers, 60 x 144" = $15,080

Power: 15 H.P. each--30 H.P. total

Davenport Press

On pressing potatoes large size, 1A, will press 75 tons per 24 hours;

i.e., 150,000 lbs./24 hours

5 H.P. motor required.

Cost complete $6,630.00

# COST ESTIMATE

## Grind, Press and Dry in Roto-Louvre

### BASIS

125 Working Days
2,500 Bushels potatoes per day. 60 lbs. per bushel
150,000 lbs./24 hours = 6,250 lbs. per hour

### CAPITAL COSTS

#### Equipment

| | | |
|---|---|---|
| 1 Washer | $ 750.00 | |
| 1 Pump, water supply | 225.00 | |
| 1 Conveyor, washer to hammermill | 2,600.00 | |
| 1 Hammermill | 1,100.00 | |
| 1 Mixing conveyor to Davenport | 385.00 | |
| 1 Syntron feeder | 115.00 | |
| 1 #1A Davenport press | 6,630.00 | |
| 1 Screw conveyor, feed to Roto-Louvre, | 385.00 | |
| 1 Roto-Louvre dryer, 5' x 20' | 19,000.00 | |
| 1 Discharge conveyor | 1,200.00 | |
| Erection, installation, supports and platforms | 8,937.00 | |
| Total Equipment | | $41,327.00 |

#### Building

Sheet iron hung on structural frame
One section: 50' x 35' x 15' = 26,250 cu.ft.
One section: 50' x 20' x 30' = 30,000 cu.ft.
Total 56,250 cu.ft.

Cost per cubic foot, including concrete floor--heat and light = $.16

56,250 x $.16 = $9,000. Fire wall = $580 — $ 9,580.00

TOTAL CAPITAL COST — $50,907.00

# COST SHEET

## BASIS

150,000 lbs. Potatoes per 24 hours = 6,250 lbs./hour

## MATERIAL

Potatoes: Nil

Lime: 0.8% on weight of potatoes
150,000 x .008 = 1,200 lbs./24 hours
Hydrated lime $.01/lb.
1,200 x $.01 = $12.00

Water for Washing

Water taken from river--have only pumping cost. This item is shown under power cost.

Total Material Cost $ 12.00

## LABOR

Per Shift. Three 8-hour shifts.

| | | | |
|---|---|---|---|
| 2 men - Washers, | $.90/hr. | $1.80 x 8 = | $14.40 |
| 1 man - Davenport, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Roto-Louvre, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Helper, | .75/hr. | .75 x 8 = | 6.00 |
| | | Per Shift | $34.80 |

Total for 3 Shifts $104.40

PRIME COST $116.40

## FACTORY OVERHEAD

### Supervision

| | |
|---|---|
| Superintendent \$20/day, | \$20.00 |
| 2 Asst. superintendents \$10/day, each, | \$20.00 |
| 1 Mechanic at \$1.20/hour, | \$ 9.60 |
| Total | \$49.60 |

### Power

| | | | |
|---|---|---|---|
| Washer, | 3 H.P. | 9.2 | 9.2 |
| Pump, | 2 H.P. | 6.0 | 6.0 |
| Hammermill, | 10 H.P. | 28 | 28.0 |
| Feeder, | | 1.36 | 1.36 |
| Mixing conveyor, | 3/4 H.P. | 2.8 | 2.8 |
| Davenport press, | 5 H.P. | 15.0 | 15.0 |
| Roto Louvre dryer, | 15 H.P. | 38 | 38.0 |
| Conveyor, | 2 H.P. | 6 | 6.0 |
| Conveyor, | 3 H.P. | 9.2 | 9.2 |
| | | Total | 115.56 |

At 220 volts, 3 phase, K.W. =

$$\frac{115.56 \times 220 \times 1.73 \times .8}{1{,}000} = 35.19 \text{ K.W.}$$

| | |
|---|---|
| 35.19 x 24 = | 844.6 K.W.H. |
| For lighting = | 5 K.W.H. |
| Total | 849.6 K.W.H. |

Cost of current: Based on \$.05/1st 1000/mo.; \$.03/next 3000/mo.; \$.01 on all over 4000 K.W.H./mo.

25 Working days per mo. 25 x 850 = 21,250 K.W.H./mo.

| | |
|---|---|
| 1,000 K.W.H. at \$.05 = | \$ 50.00 |
| 3,000 K.W.H. at \$.03 = | 90.00 |
| 17,250 K.W.H. at \$.01 = | 172.50 |
| | \$312.50 |

$$\frac{\$312.50}{21{,}250} = \$.0147/\text{K.W.H.}$$

850 x .0147 = \$12.50

| | | |
|---|---|---|
| Fuel for Drying | \$28.35 | |
| Maintenance and Supplies | \$25.00 | |
| TOTAL FACTORY OVERHEAD | | \$115.45 |
| FACTORY COST | | \$231.85 |

FIXED CHARGES

125 Days operation

Interest at 5%

$.05 \times \$50,907 = \$2,545.35$

For 125 days operation, $\frac{\$2,545.35}{125} = \$20.36$

Taxes at 2%

$.02 \times \$50,907 = \$1,018.14$

For 125 days operation, $\frac{\$1,018.14}{125} = \$\ 8.15$

Insurance at 0.5%

$.005 \times \$50,907 = \$254.54$

For 125 days operation, $\frac{\$254.54}{125} = \$\ 2.04$

Social Security. 1-1/2% on first $2,500

Full payroll for 125 days = $19,250

$\$19,250 \times .015 = \$288.75$

For 125 days = $\frac{\$288.75}{125} = \$\ 2.31$

Depreciation--The depreciation rates will be high due to the fact that the plant will be shut down approximately 7 months of the year.

| | | | |
|---|---|---|---|
| Buildings, 10%/year = | .10 x $ 9,580 = | $ 958.00 |
| Equipment, 15%/year = | .15 x $41,327 = | $6,199.05 |
| | Total | $7,157.05 |

For 125 days operation, $\frac{\$7,157.05}{125} = \$57.26$

TOTAL FIXED CHARGES $ 90.12

COST TO MAKE

| | |
|---|---|
| Materials | $ 12.00 |
| Labor | 104.40 |
| Factory overhead, | 115.45 |
| Fixed costs | 90.12 |

Total $321.97

YIELDS AND COSTS

150,000 lbs./24 hours. 6,250 lbs./hour

Raw material 20% solids

6,250 x .20 = 1,250 lbs. solids/hour

Lose 20% solids through Davenport press

1,250 x .8 = 1,000 lbs. solids/hour

Material contains 12% moisture

$\frac{1,000}{.88}$ = 1,136 lbs. finished product per hour (12% $H_2O$)

For 24 hours.

1,136 x 24 = 27,264 lbs. (12% $H_2O$)

27,264 lbs. cost to make $321.97

Cost per Pound (12% $H_2O$)

$$\frac{\$321.97}{27,264} = \$.0118$$

Cost per Ton (12% $H_2O$) $23.60

Cost per Pound Dry Solids

$$\frac{\$321.97}{24,000} = \$.0134$$

Cost per Ton Dry Solids $26.80

CALCULATIONS

Heat Requirements for Evaporation in Roto-Louvre Dryer

6,250 lbs./hour at 80% water and 20% solids, therefore,
5,000 lbs. water; 1,250 lbs. solids

Through Davenport press removes 62% of original water

5,000 x .62 = 3,100 lbs. water squeezed out per hour,
therefore, 1,900 lbs. of water/hour in product from Davenport
Davenport also squeezes out 20% of solids
1,250 x .80 = 1,000 lbs. of solids/hour from Davenport.
From Davenport/hour.

1,000 lbs. solids) 34.4%
1,900 lbs. water ) 65.6%

Product to contain 12% water

$\frac{1000}{.88}$ = 1,136 lbs. finished product per hour (12% water)

1,136 -1,000 = 136 lbs. water in finished product/hour

1,900 - 136 = 1,764 lbs. water to be evaporated per hour

1,136 x 24 = 27,264 lbs. product/24 hours = 13.6 tons

Per hour
1,000 lbs. solids Sp.Ht. .83
1,764 lbs. $H_2O$ " " 1.0

| | | | | |
|---|---|---|---|---|
| 1,000 x | .83 | x (212-60) = | 126,160 | B.t.u./hour |
| 1,764 x | 1.0 | x (212-60) = | 268,128 | B.t.u./hour |
| 1,764 x 970.3 | | = | 1,711,080 | B.t.u./hour |
| | | Total | 2,105,368 | B.t.u./hour |

Allowing for radiation and other losses there will be
required 100,642,500 B.t.u./24 hours.

From this the fuel cost will be $28.35

# COST ESTIMATE

## Grind, Press, Regrind and Dry in Steam Tube Drier

BASIS

125 Working Days
2,500 Bushels potatoes per day = 60 lbs. per bushel
150,000 Lbs. per 24 hours = 6,250 lbs. per hour

CAPITAL COSTS

Equipment

| | | |
|---|---|---|
| 1 Washer | $ 750.00 | |
| 1 Pump, water supply | 225.00 | |
| 1 Conveyor to hammermill | 2,600.00 | |
| 1 Hammermill | 1,100.00 | |
| 2 Hammermills (cheap) | 1,200.00 | |
| 1 Mixing conveyor to Davenport | 385.00 | |
| 1 Syntron feeder (lime) | 115.00 | |
| 1 #1A Davenport press | 6,630.00 | |
| 1 Screw conveyor, feed to dryer | 385.00 | |
| 1 Steam tube dryer 6' x 30' | 7,600.00 | |
| 1 Discharge conveyor | 1,200.00 | |
| 1 Mixing conveyor | 385.00 | |
| Erection, installation and platforms | 7,500.00 | |
| Total Equipment | | $30,075.00 |

Building

Sheet iron hung on structural frame

One section 50' x 15' x 30' = 22,500 cu.ft.
One section 50' x 15' x 40' = 30,000 cu.ft.
Total 52,500 cu.ft.

Cost per cubic foot, including concrete floor--
heat and light--16 cents per cu.ft.

Total 52,500 x $.16 = $ 8,400.00

CAPITAL COSTS-Continued

Boilers--housed ready to run

Steam required 2,408 lbs./hour

Steam pressure 90 lbs. gauge

Enthalpy at 90 lbs. gauge = 1,188 B.t.u./lb.

$$\frac{1,188-(62-32)}{970.3} = 1.19 \text{ factor of evapn.}$$

2,408 x 1.19 = 2,865.5 lbs. from and at 212° F.

$$\frac{2,865.5}{34.5} = 83 \text{ B.H.P.}$$

Cost per B.H.P. = $40.00

| | |
|---|---|
| Total | 83 x $40. = $ 3,320.00 |
| TOTAL CAPITAL COST | $41,795.00 |

# COST SHEET

## BASIS

150,000 lbs. Potatoes per 24 hours = 6,250 lbs./hour

## MATERIAL

Potatoes: Nil

Lime:

0.8% on weight of potatoes

150,000 x .008 = 1,200 lbs./24 hours

Hydrated lime = $.01/lb.

1,200 x $0.01 = $12.00

Water for Washing

Water taken from river--have only pumping cost.
This item is shown under power cost.

| | |
|---|---|
| Total Material Cost | $ 12.00 |

## LABOR

Per Shift. Three 8-hour shifts.

| | | | |
|---|---|---|---|
| 2 men - Washers, | $.90/hr. | $1.80 x 8 = | $14.40 |
| 1 man - Hammermill & Davenport, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Dryer, | .90/hr. | .90 x 8 = | 7.20 |
| 1 man - Helper, | .75/hr. | .75 x 8 = | 6.00 |
| | | Per Shift | $34.80 |

| | |
|---|---|
| Total for 3 Shifts | $104.40 |
| PRIME COST | $116.40 |

FACTORY OVERHEAD

Supervision

| | | |
|---|---|---|
| Superintendent | $20/day, | $20.00 |
| 2 Asst. superintendents | $10/day ea., | $20.00 |
| 1 Mechanic at | $1.20/hour | $ 9.60 |
| | Total | $49.60 |

Power

| | | | |
|---|---|---|---|
| Washer, | 3 H.P. | 9.2 | 9.20 |
| Pump, | 2 H.P. | 6. | 6.00 |
| Hammermill, | 10 H.P. | 28. | 28. |
| Feeder, | | 1.36 | 1.36 |
| Mixing conveyor, | 3/4 H.P. | 2.8 | 2.8 |
| Davenport, | 5 H.P. | 15.0 | 15.0 |
| Hammermills, | 5 H.P. | 15.0 ea. | 30.0 |
| Dryer, | 15 H.P. | 38. | 38.0 |
| Conveyor, | 2 H.P. | 6 | 6.00 |
| Mixing conveyor, | 3 H.P. | 9.2 | 9.20 |
| Conveyor, | 3 H.P. | 9.2 | 9.20 |
| | | Total | 154.76 amp. |

At 220 volts, 3 phase, K.W.=

$$\frac{154.76 \times 220 \times 1.73 \times .8}{1,000} = 47.121 \text{ K.W.}$$

| | | |
|---|---|---|
| 47.121 x 24 = | 1,130.9 | K.W.H. |
| For lighting = | 5 | K.W.H. |
| | 1,135.9 | K.W.H. |

Cost of current: Based on $.05/1st 1000/mo.; $.03/next 3000/mo.; $.01 on all over 4000 K.W.H./mo.

25 working days per mo. 25 x 1,135.9 = 28,398 K.W.H./mo.

| | | |
|---|---|---|
| 1,000 K.W.H. at $.05 = | $ 50.00 | |
| 3,000 K.W.H. at $.03 = | 90.00 | $\frac{\$383.98}{28,398}$ = $.0135/K.W.H. |
| 24,398 K.W.H. at $.01 = | 243.98 | |
| | $383.98 | |

Total 1135.9 x $.0135 = $15.34

Steam

2,408 lbs./hour
For 24 hours = 57,792 lbs.
Steam costs 40 cents per 1,000 lbs.

Total 57.79 x $0.40 = $23.12

Maintenance and Supplies $25.00

TOTAL FACTORY OVERHEAD $113.06

FACTORY COST $229.46

FIXED CHARGES

125 Days operation

Interest at 5%

$.05 \times \$41,795 = \$2,089.75$

For 125 days operation, $\frac{\$2,089.75}{125} = \$16.72$

Taxes at 2%

$.02 \times \$41,795 = \$835.90$

For 125 days operation, $\frac{\$835.90}{125} = \$\ 6.68$

Insurance at 0.5%

$.005 \times \$41,795 = \$208.98$

For 125 days operation, $\frac{\$208.98}{125} = \$\ 1.67$

Social Security. 1-1/2% on first $2,500

Full payroll for 125 days = $19,250

$\$19,250 \times .015 = \$288.75$

For 125 days operation, $\frac{\$288.75}{125} = \$\ 2.31$

Depreciation--The depreciation rates will be high due to the fact that the plant will be shut down approximately 7 months of the year.

| | | | |
|---|---|---|---|
| Buildings, | 10%/year = .10 x $ 8,400 | = | $ 840.00 |
| Equipment, | 15%/year = .15 x $30,075 | = | $4,511.25 |
| Boilers & Build., | 12%/year = .12 x $ 3,320 | = | $ 398.40 |
| | Total | | $5,749.65 |

For 125 days operation, $\frac{\$5,749.65}{125} = \$45.99$

TOTAL FIXED CHARGES $73.37

COST TO MAKE

| | |
|---|---|
| Materials | $ 12.00 |
| Labor | 116.40 |
| Factory overhead | 113.06 |
| Fixed costs | 73.37 |

Total $314.83

YIELDS AND COSTS

150,000 lbs./24 hours = 6,250 lbs./hour

Raw material = 20% solids

6,250 x .20 = 1,250 lbs. solids/hour

Lose 20% solids through Davenport press

1,250 x .8 = 1,000 lbs. solids/hour

Material contains 12% moisture

$\frac{1,000}{.88}$ = 1,136 lbs. finished product/hour (12% $H_2O$)

For 24 hours.

1,136 x 24 = 27,264 lbs. (12% $H_2O$) (13.6 tons)

27,264 lbs. cost to make \$314.83

Cost per Pound (12% $H_2O$)

$\frac{\$314.83}{27,264}$ = \$.0115

Cost per Ton (12% $H_2O$) \$23.00

Cost per Pound Dry Solids

$\frac{\$314.83}{24,000}$ = \$.0131

Cost per Ton Dry Solids

\$26.20

CALCULATIONS

Dryer

Steam tube

BASIS

150,000 lbs./24 hours = 6,250 lbs./hour
5,000 lbs. water and 1,250 lbs. solids/hour
Through Davenport press
Lose 62% of original water
5,000 x .62 = 3,100 lbs. water squeezed out/hour
Remains 1,900 lbs. water/hour
Lose 20% solids through Davenport
1,250 x .8 = 1,000 lbs. solids remain/hour
From Davenport/hour

| | | |
|---|---|---|
| 1,000 lbs. solids | ) | 34.4% |
| 1,900 lbs. water | ) | 65.6% |
| 2,900 lbs. Total/hour | | |

Finished solids to have 12% water

$$\frac{1,000}{.88} = 1,136 \text{ lbs. product/hour } (12\% \; H_2O)$$

1,136 -1,000 = 136 lbs. water left in material/hour

1,900 -136 = 1,764 lbs. water to be evaporated/hour

Allowing an evaporation rate of 1.4 lbs. of water per hour per square foot of heating surface. (From test on steam tube dryer in pilot plant.)

Heating surface required, $\frac{1,764}{1.4} = 1,260$ sq.ft.

Heat Load

| | | | | |
|---|---|---|---|---|
| 1,000 x | .83 x (212-60) | = | 126,160 | |
| 1,764 x | 1.0 x (212-60) | = | 268,128 | |
| 1,764 x 970.3 | | = | 1,711,609 | |
| | Total | | 2,105,897 | B.t.u./hour |

Steam at 90 lbs. gauge = 331° F.

$t_1 = 331-60 = 271°$ F.; $t_2 = 210-140 = 70°$ F.

$$\Delta t_m = \frac{270-70}{2.3 \log \frac{270}{70}} = \frac{200}{2.3 \log 3.85} = \frac{200}{1.35} = 148° \text{ F.}$$

Allowing U = 10 B.t.u./sq.ft./hr./° F. (commonly used for steam tube dryers)

$Q = UA\Delta t$

$2,105,897 = 10 \times A \times 148$

$A = \frac{2,105,897}{10 \times 148} = 1,423$ sq.ft. heating surface for U = 10

CALCULATIONS

Heat Load-Continued

Using a rate of 1.4/sq.ft./lb./hr.

$$U = \frac{2,105,897}{1,260 \times 148} = 11.29$$

Size of dryer = 6' dia. x 30' long

Radiation loss. 0.5 B.t.u./sq.ft./hr./°F.

18.8 x 0.5 x 30 x 120 = 33,840 B.t.u./hour

Total heat to be supplied = 2,105,897 + 33,840 = 2,139,737 B.t.u./hr.

Fuel Consumption

Steam at 90 lbs. gauge
Heat available at 90 lbs. gauge = 886 B.t.u./lb.

$$\text{Steam required} = \frac{2,139,737}{886} = 2,415 \text{ lbs./hour}$$

Cost of steam at $.40/1,000 lbs. = $.966/hour

For 24 hours = $23.18

Horsepower required 12. = 15 H.P. motor

Cost of dryer, $7,600.00

Overall dimensions = 37'-3" x 7'-4"

River Water Used for Starch Work (W.W.H. report)

Use--250 g.p.m. for washing 156,700 lbs./day (8 hours)
250 x 60 = 15,000 gals. wash 19,588 lbs. potatoes

$$\frac{15,000}{19,588} = .767 \text{ gallons water per lb. potatoes}$$

Say 3/4 gallon per pound potatoes

This for starch recovery -

For feed purposes potatoes do not need to be as clean--
Say 1/2 the amount of water or 3/8 gallon water per lb. potatoes
150,000 lbs./24 hours
150,000 x 3/8 = 56,300 gals./day (24 hours)

$$\frac{56,300}{24 \times 60} = \frac{56,300}{1,440} = 39.1 \text{ g.p.m.}$$

Pump size = 50 g.p.m.

With starter and switch, $225.00
Motor required, 2 H.P.

THE J. B. BEAIRD COMPANY, INC.

Mfg. Challenger Dehydrators

5800-6300 St. Vincent Ave.

SHREVEPORT, LA.

October 25, 1946.

Mr. F. L. Robinson, Vice President
Farm Crops Processing Corp.
4th & Jones St.
Omaha 8, Nebraska

Dear Mr. Robinson:

Replying to your letter of the 16th, we must tell you that in our opinion the dehydration of Irish potatoes on a commercial basis has so far proven to be far from satisfactory.

In the field under successful operations in the hands of numerous owners, we have over 125 of our Challenger Dehydrators successfully processing sweet potatoes, and various crops such as alfalfa, lespedez, Johnson grass, soybean hay, etc. Several of these owners have conducted extensive experiments in drying Irish potatoes, but with very indifferent success. The cost of drying is excessive and the hourly production quite low. Hence, unless one could secure an extremely high price for the dried material, we could not conscientiously recommend the operation as a commercial success.

The Irish potato as you know differs radically in consistency from the sweet potato. There is practically no fiberous matter, hence Irish potatoes tend to gum up the machine, are particularly susceptible to scorching and due to high moisture content, are extremely slow in drying.

Feeling that you will undoubtedly be interested in other features of dehydration, we are taking the liberty of enclosing a little booklet recently prepared and while it is to be regretted that we cannot offer too much encouragement on Irish potatoes, it is hoped that some of your constituents may have use for dehydrators on other commodities.

Yours very truly,

THE J. B. BEAIRD COMPANY INC.

/s/ C. S. Finegan
Manager of Sales

CSF/tm

# FEEDING TESTS WITH DRIED POTATOES

The value of dried potatoes, as compared to corn as a stock feed was calculated by two methods:

1. The ratio of the net energy value[1/] of No. 2 corn in therms to that of dried potatoes at 12 percent moisture. This ratio equals $\frac{71.8}{79.2} = 0.907$, say 0.9.

   The net energy value of the dried potatoes was calculated on the assumption that the solids of the raw potato were not appreciably altered during the drying operation.

2. Likewise the average feeding costs based on 100 pounds gain, on corn rations as compared with dried potato rations gave a ratio of 0.88. These feeding costs are based on five feeding experiments conducted at the Colorado Agricultural Experiment Station and the North Dakota Agricultural Experiment Station.

   The detailed data relating to these tests are shown in Tables II to VI inclusive. These data indicate that the dried potato rations used in the two steer feeding tests were equal to the corn ration used, based on cost of feed per 100 pounds gain. In the case of lamb feeding, the potato ration in one case was superior to corn and in the second case it was much inferior to corn. In one experiment the potato ration for feeding pigs was equal to only 52 percent of the corn ration. All of the calculations are based on dried potatoes and corn at $50.00 per ton.

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1/ Feeds and Feeding, 20th edition, Morrison, Appendix, Table II, pp. 997-998.

Table I shows the comparative cost based on five feeding experiments per 100 pounds gain of livestock when fed on a ration which contains corn or dried potatoes. Both corn and dried potatoes valued at $50.00 per ton.

Table I

| Livestock | Cost of Feed per 100 Lbs. Gain | | Ratio Cost $\frac{\text{Corn Ration}}{\text{Potato Ration}}$ |
|---|---|---|---|
| | Corn Ration | Potato Ration | |
| Steers | $21.04 | $20.42 | 1.03 |
| Steers | 16.24 | 16.20 | 1.00 |
| Lambs | 17.36 | 14.82 | 1.17 |
| Lambs | 12.15 | 17.69 | .69 |
| Pigs | 10.45 | 20.28 | .52 |
| | | Ave. | .88 |

Table II

Potatoes Increase Value of Corn Fodder and
Alfalfa Hay Silages for Cattle Feed

Colorado Farm Bulletin; Vol. VII, No. 4, July-August, 1945

| | Per 100 Lbs. Gain | | | |
|---|---|---|---|---|
| | Lbs. Feed Required | | Cost of Feed | |
| Ground Corn | 684.6 | | 15.06 | |
| Dehydrated Potatoes | | 663.6 | | 17.15 |
| Cottonseed Meal | 45.4 | 43.9 | 1.47 | 1.43 |
| Corn Silage | 206.8 | 194.5 | .78 | .73 |
| Alfalfa Hay | 178.1 | 178.3 | 1.60 | 1.61 |
| Mineral Mix | 1.5 | 1.4 | .06 | .05 |
| Salt | 1.4 | .6 | .01 | .01 |
| Feed cost per cwt. gain | | | | |
| Ground Corn, $44.00/ton | | | 18.98 | |
| Dehydrated Potatoes, $51.70/ton | | | | 20.98 |
| Ground Corn, $50.00/ton | | | 21.04 1/ | |
| Dehydrated Potatoes, $50.00/ton | | | | 20.42 1/ |

1/ Calculated at E.R.R.L.

"Dehydrated potato meal, compared to ground corn, appeared to be almost as palatable and produced slightly higher gains in this experiment. With corn at $44.00 per ton the dehydrated potato meal was worth $45.70 per ton. However, the potato meal was charged at $51.70 per ton in this experiment which increased the cost per 100 weight gain above that of the other lots."

With both corn and dehydrated potatoes at $50.00 per ton, the cost of feed per 100 weight gain was slightly less when dehydrated potatoes were used. (Based on E.R.R.L. calculations).

Table III

Fattening Steers with Dehydrated Potatoes and Silage

Colorado Farm Bulletin; Vol. VIII, No. 3, May-June, 1946

| | Per 100 Lbs. Gain | | | |
|---|---|---|---|---|
| | Lbs. Feed Required | | Cost of Feed | |
| Dehydrated Potato Cubes | 305.7 | | 7.64 | |
| Ground Corn | | 300.5 | | 7.51 |
| Dried Beet Pulp | 306.0 | 300.5 | 5.20 | 5.11 |
| Cottonseed Meal | 10.6 | 10.6 | .35 | .35 |
| Alfalfa Hay | 165.3 | 189.2 | 1.90 | 2.18 |
| Corn Silage | 237.3 | 234.2 | 1.07 | 1.05 |
| Mineral Mixture | 1.6 | 1.4 | .03 | .03 |
| Salt | 1.2 | 1.0 | .01 | .01 |
| Feed cost per cwt. gain | | | | |
| Dehydrated Potato Cubes, $50.00/ton (Arbitrary Price) | | | 16.20 | |
| Ground Corn, $50.00/ton | | | | 16.24 |

"Dehydrated potato cubes fed in this experiment gave practically as good results as ground corn from the standpoint of gains, cost of gains, and live market value. The feed replacement value of the dehydrated potatoes was equal to corn. However, when the carcasses of the steers fed dehydrated potatoes were compared to those fed corn, it was observed that they 'cut' darker and this lot ranked the lowest in the experiment."

Table IV

Dehydrated Potatoes and Alfalfa Silage for Lambs

Colorado Farm Bulletin; Vol. VIII, No. 2, March-April, 1946

| | Per 100 Lbs. Gain | | | |
|---|---|---|---|---|
| | Lbs. Feed Required | | Cost of Feed | |
| Dehydrated Potato Cubes | | 296 | | 7.40 |
| Whole Corn | 334 | | 8.02 | |
| Chopped Alfalfa | 693 | 571 | 9.01 | 7.42 |
| Feed cost per cwt. gain | | | | |
| Whole Corn, $48.00/ton | | | 17.03[1] | |
| Dehydrated Potato Cubes, $50.00/ton | | | | 14.82[1] |
| Whole Corn, $50.00/ton | | | 17.36[1] | |

1/ Calculated at E.R.R.L.

With both corn and dehydrated potatoes at $50.00 per ton, the cost of feeding the above ration with dehydrated potatoes was 86 percent of the cost of the ration with whole corn per 100 pounds gain in weight.

Table V

Dehydrated Potatoes for Sheep

M. L. Buchanan, Bimonthly Bulletin North Dakota Agricultural Experiment Station, Vol. VIII, No. 6, July-August, 1946

| | Total Feed | | | |
|---|---|---|---|---|
| | Lbs. of Feed Required | | Cost of Feed | |
| Grass Hay | 2,765 | 2,765 | 13.85 | 13.85 |
| Soybean Oil Meal | 220 | 330 | 6.60 | 9.90 |
| Yellow Corn | 1,272 | | 28.39 1/ | |
| Dehydrated Potatoes | | 1,272 | | 12.72 |
| Total feed cost based on | | | | |
| Corn at $1.25/bu. = $44.64/ton | | | 48.84 1/ | |
| Dehydrated Potatoes at $20/ton | | | | 36.47 |
| Feed cost per cwt. gain | | | 11.36 1/ | 11.61 1/ |
| Feed cost per cwt. gain based on | | | | |
| Yellow corn at $50/ton | | | 12.15 1/ | |
| Dehydrated Potatoes at $50/ton | | | | 17.69 1/ |

1/ Calculated at E.R.R.L.

"The results of this trial indicate that dehydrated potatoes as produced by present processes are a palatable feed for sheep. The sheep did well throughout the feeding period and gained at the rate of 0.225 pounds per day on the potato ration as compared to 0.307 on the corn ration. This would indicate that dehydrated potatoes may be used as a substitute for grain in sheep rations if care is taken to provide additional protein and minerals."

With both corn and dehydrated potatoes at $50.00 per ton, the cost of feed per 100 weight gain was about 46 percent more when dehydrated potatoes were used in the ration than when corn was used. (Based on E.R.R.L. calculations).

Table VI

Cooked Potato Silage Gives Good Results in Pig-Feeding Experiments

Colorado Farm Bulletin; Vol. VII, No. 6, Nov.-Dec., 1945

| | Per 100 Lbs. Gain | | | |
|---|---|---|---|---|
| | Lbs. Feed Required | | Cost of Feed | |
| Ground Corn | 354.49 | | 8.58 | |
| Dehydrated Potato Pulp | | 644.10 | | 16.65 |
| Soybean Meal | 46.87 | 122.02 | 1.55 | 4.03 |
| Alfalfa Meal | 3.07 | 11.20 | .03 | .12 |
| Minerals | 1.17 | 3.09 | .01 | .03 |
| Ground Corn, $48.40/ton | | | 10.17 1/ | |
| Dehydrated Potato Pulp, $51.70 | | | | 20.83 1/ |
| Ground Corn, $50./ton | | | 10.45 1/ | |
| Dehydrated Potatoes, $50.00 | | | | 20.28 1/ |

1/ Calculated at E.R.R.L.

With both corn and dehydrated potato pulp at $50.00 per ton, it costs about twice as much to feed with the dehydrated potato pulp as with ground corn based on 100 pound gain in weight.